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## A NEW SERIES OF SUNSHINE MAPS OF THE UNITED STATES\*

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Sunshine charts are of two classes. They either (1) give the number of hours of bright sunshine, as determined by means of sunshine recorders; or (2) they show the duration of sunshine in percentages of the possible duration. These percentages may be obtained from the cloudiness estimated by eye at regular hours, or by comparing the total number of hours of bright sunshine, as indicated by sunshine recorders, with the total possible number of hours and expressing the results as percentages. When eye observations of cloudiness are available, but sufficient instrumental records of sunshine are lacking, the former method is the one naturally adopted. Sunshine charts of both kinds have been published for the United States.<sup>1</sup> For publication in the forthcoming section on "Climate" in the "Atlas of American Agriculture," a new series of sunshine maps of the United States has recently been prepared by Mr. Joseph Burton Kincer, of the U. S. Weather Bureau. In view of the long delay in the issue of the "Atlas," these new maps have been given advance publication in the *Monthly Weather Review*.<sup>2</sup>

Each of the methods of presenting sunshine data has its advantages, and Mr. Kincer makes use of both. Charts and curves show the mean solar time of sunrise and sunset and the average length of the day (sunrise to sunset), representing the possible maximum amount of sunshine for different seasons of the year. There are charts indicating, for each month, the average amount of sunshine in hours per day; also charts and curves showing the seasonal and annual distribution in percentages of the possible amount and the percentage of days clear, partly cloudy, and cloudy. The diurnal distribution of sunshine is presented graphically. A table gives, for each month and for the year, the average percentages of the possible amount of sunshine for all stations where continuous automatic records are made. This includes practically all regular reporting stations. The basic data are for the uniform period of 20 years, 1895 to

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\* This is the sixth in a series of articles by the present writer on the climatology of the United States. The previous articles were: Climatic Subdivisions of the United States, *Bull. Amer. Geogr. Soc.*, Vol. 47, 1915, pp. 672-680; Rainfall Types of the United States, *Geogr. Rev.*, Vol. 4, 1917, pp. 131-144; Rainy Days and Rain Probability in the United States, Vol. 7, 1919, pp. 44-48; Frost in the United States, *Geogr. Rev.*, Vol. 7, 1919, pp. 339-344; Cloudiness in the United States, *Geogr. Rev.*, Vol. 9, 1920, pp. 347-356; New Monthly and Seasonal Rainfall Maps of the United States, *Geogr. Rev.*, Vol. 10, pp. 173-181.

<sup>1</sup> See R. DeC. Ward: Bibliographic Note on Sunshine in the United States, *Monthly Weather Rev.*, Vol. 47, Nov., 1919, pp. 794-795.

<sup>2</sup> J. B. Kincer: Sunshine in the United States, *Monthly Weather Rev.*, Vol. 48, Jan., 1920, pp. 12-17.

1914. The percentages of the possible amounts are for the eight-year period 1905-1912. Mr. Kincer's charts and text, inasmuch as they are based on data covering the same period of time, will doubtless for many years remain the standard discussion of the sunshine of the United States.

The map below (Fig. 1), redrawn, with the addition of shading, from Chart I of Mr. Kincer's paper, shows the distribution of sunshine for the year, expressed in percentages of the possible amount. The latter is essentially the same for all parts of the country, the average possible

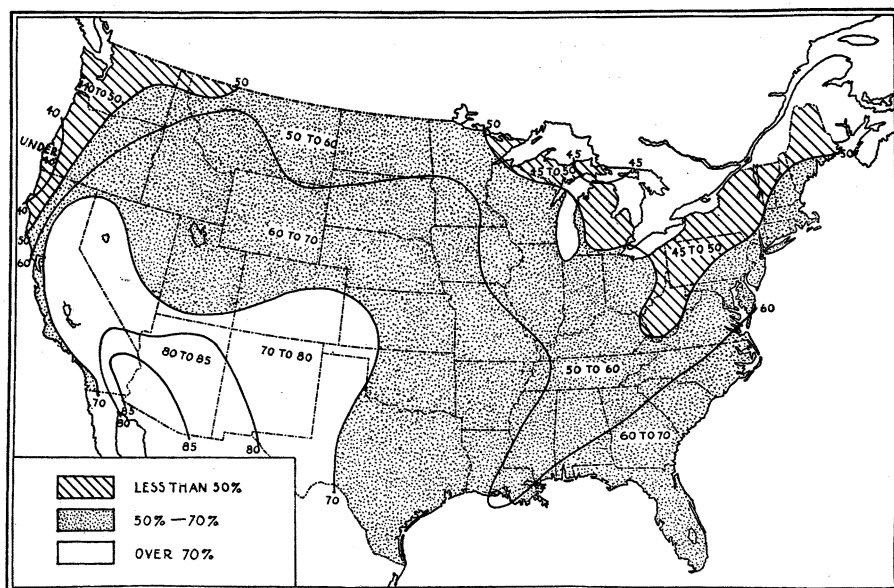


FIG. 1.—Map of the United States showing mean annual sunshine expressed in percentages of the possible amount. Scale 1:45,000,000 (after J. B. Kincer).

yearly amount at latitude  $25^{\circ}$  N. being 4,437.2 hours and at latitude  $49^{\circ}$  N. 4,472.6 for a 365-day year. The maximum percentage of sunshine (over 85 per cent) is in the extreme southwestern interior. The minimum (under 40 per cent) is along the northern Pacific coast. The Lake region, the northern and central portions of the Appalachian area, and the northeast, have slightly higher percentages (45 to 50 per cent). Elsewhere east of the Mississippi River and over the northern tier of states from the Upper Great Lakes westward to the Rockies, the percentages range from 50 to 60. They are somewhat higher in the southeast, especially in the Florida peninsula. Between the Mississippi River and the Rocky Mountains the annual percentage is generally between 60 and 70, and the same values hold for the central Rocky Mountain region and northern Plateau states. There is thus seen to be a decrease in the amount of sunshine from the southwestern interior to the northwest, north, and north-

east and, to a less degree, to the east. For the United States as a whole the average annual amount of sunshine is about 60 per cent of the possible amount.

The sunshine conditions for the four seasons, given in percentages of the possible, show, for the country as a whole, 48 per cent in winter, 60 per cent in spring, 68 per cent in summer, and 60 per cent in autumn. The maximum seasonal amount of sunshine is 95 per cent—in the valley of California in summer. The minimum amount is under 30 per cent—over the northwest in winter. The annual variation is greatest in the northwest and over the Great Lakes. Both of these regions have marked seasonal variations in cyclonic activity, and both have marked effects of water areas upon the moisture-content of the prevailing winds. The charts showing the average number of hours of bright sunshine daily, by months, indicate quite emphatically the general northward migration of summer conditions, with more sunshine as the season advances from the colder to the warmer months. The summer months are the sunniest in most sections, while spring and autumn have the most sunshine over certain smaller areas. July is the time of maximum sunshine over about one-half of the country. The increase in the amount of sunshine from winter to summer is very marked over the northern portion of the United States.

The annual percentages of clear, partly cloudy, and cloudy days have also been charted. The percentage of clear days ranges from about 20-25 per cent on the northern Pacific coast and over the Lake region to over 90 per cent in the extreme southwestern interior—in southeastern California and southwestern Arizona. On the other hand, the percentage of cloudy days is at a minimum (5 per cent) in the last-named district and at a maximum (over 40 per cent) in the other two areas. For the country as a whole there is less sunshine in the early morning hours; there is a secondary minimum in the late afternoon, and a maximum near noon. This general rule and the departures from it may be explained by the conditions of local cloud or fog formation.

Many interesting comparisons suggest themselves as regards sunshine between Europe and the United States. The contrast between western Europe and eastern North America was clearly emphasized by Woeikof a number of years ago.<sup>3</sup> He pointed out that the American coast has great advantages in respect to sunshine, especially if stations having similar temperatures and not stations in the same latitudes are considered. "Not only is the duration of sunshine longer (on the American coast) but the air is clearer, especially in the colder months. This contrast is very strikingly emphasized on the voyage from England to the United States."

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<sup>3</sup> A. Woeikof: *Die Klimate der Erde*, Jena, 1887, Part II, p. 45.